THE OXFORD INSTITUTE FOR ENERGY STUDIES
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UNIVERSITY OF OXFORD

Cashflow Modelling for the Energy Industry

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The Economics of Energy Corporations (2)

Outline of the course

Overall objective – understand how senior management use economic models to make investment decisions

1. Introduction to key themes in the global energy market
2. **Introduction to financial modelling as a management tool**
    1. **Understanding some key concepts**
3. Building the asset – estimating costs
4. Generating revenues – production and prices
5. Operating costs – running the plant and paying the government
6. Calculating a discounted cashflow
    1. Why is it important
    2. How is it used to make decisions
7. Testing the investment decisions: running some numbers under different assumptions
8. Answering your questions

The Question

- Value an energy asset given specific assumptions
  - Examples of a shale gas field and a power station
- Test the sensitivity of the model
- Provide an investment conclusion for senior management

- Detailed breakdown of company operating and financial performance
- Investment analysts are responsible for asking fundamental questions of senior management
- There is pressure to perform across a broad range of metrics
- A "Sell" recommendation can have big implications

Petroleo Brasileiro S.A. (PBR) Bad news! →

Income statement (BRLmn)	2016A	2017E	2018E	2019E	CAGR
EBITDA (adj)	69,076	96,614	119,885	120,155	20.3%
EBIDA (adj)	62,095	79,251	95,530	96,630	15.9%
Net income (op basis)	-3	21,257	35,640	35,257	N/A
EPS (adj) ($)	0.00	1.10	2.00	1.95	N/A
Diluted shares (mn)	6,522.2	6,522.2	6,522.2	6,522.2	0.0%
DPS (BRL)	0.00	0.00	0.00	1.09	N/A
Return data					**Average**
ROACE (%)	2.3	5.8	8.2	8.0	6.1
ROAE (%)	-0.0	8.7	13.8	12.1	8.6
ROMC (%)	3.3	8.4	12.3	13.2	9.3
Balance sheet and cash flow (BRLmn)					**CAGR**
Shareholders' equity	250,230	241,248	276,649	304,539	6.8%
Net debt/(funds)	316,676	266,058	195,632	142,220	-23.4%
Total debt	385,784.0	357,003.1	333,978.2	279,878.1	-10.1%
Market capital employed	585,629	521,402	481,548	432,681	-9.6%
Cash flow from operations	89,709	123,001	128,252	127,617	12.5%
Capital expenditure	-49,744	-59,698	-44,656	-47,641	N/A
Dividends paid	0	0	0	-7,128	N/A
Free cash flow	39,965	63,303	83,596	79,976	26.0%
Net cash surplus/(deficit)	-28,737	21,837	47,401	-688	N/A
Valuation and leverage metrics					**Average**
P/E (adj) (x)	N/A	8.3	4.6	4.7	5.9
EV/EBITDA (adj) (x)	7.2	4.7	3.2	2.7	4.4
EV/EBIDA (adj) (x)	8.1	5.7	4.0	3.4	5.3
Equity FCF yield (%)	67.3	106.5	140.7	134.6	112.3
Dividend yield (%)	0.0	0.0	0.0	3.9	1.0
Total debt/capital (%)	60.7	59.7	54.7	47.9	55.7
Total debt/equity (%)	154.2	148.0	120.7	91.9	128.7
NAV per share	N/A	N/A	N/A	N/A	N/A
EV/boe	N/A	N/A	N/A	N/A	N/A
Selected operating metrics					
Upstream					
Oil production (000 b/d)	2,224.3	2,185.0	2,362.2	2,531.8	
Gas production (000 cf/d)	3,396.0	3,025.1	3,015.4	3,026.4	
Total production (000 boe/d)	2,790.3	2,689.2	2,864.7	3,036.2	
Realisations ($/boe)	37.5	61.3	74.9	71.4	
Downstream					
Refining capacity (000 b/d)	N/A	N/A	N/A	N/A	
Refining throughput (000 b/d)	1,945.0	1,977.0	N/A	N/A	

Price (22-Mar-2017)	USD 9.11
Price Target	**USD 11.00**

Why Underweight? Despite an attractive NAV valuation, we believe shares will be held captive with limited upside, as the market continues to focus on the unsustainable debt levels and cash flow outlook as well as headlines surrounding the ongoing corruption investigation. Between the two share classes, we believe the preferred offer much better value and upside potential.

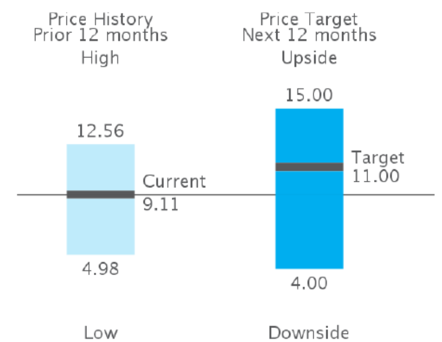
Upside case USD 15.00

Our upside case assumes a long-term Brent price deck of $90/bl in our NAV analysis plus a potential premium/discount.

Downside case USD 4.00

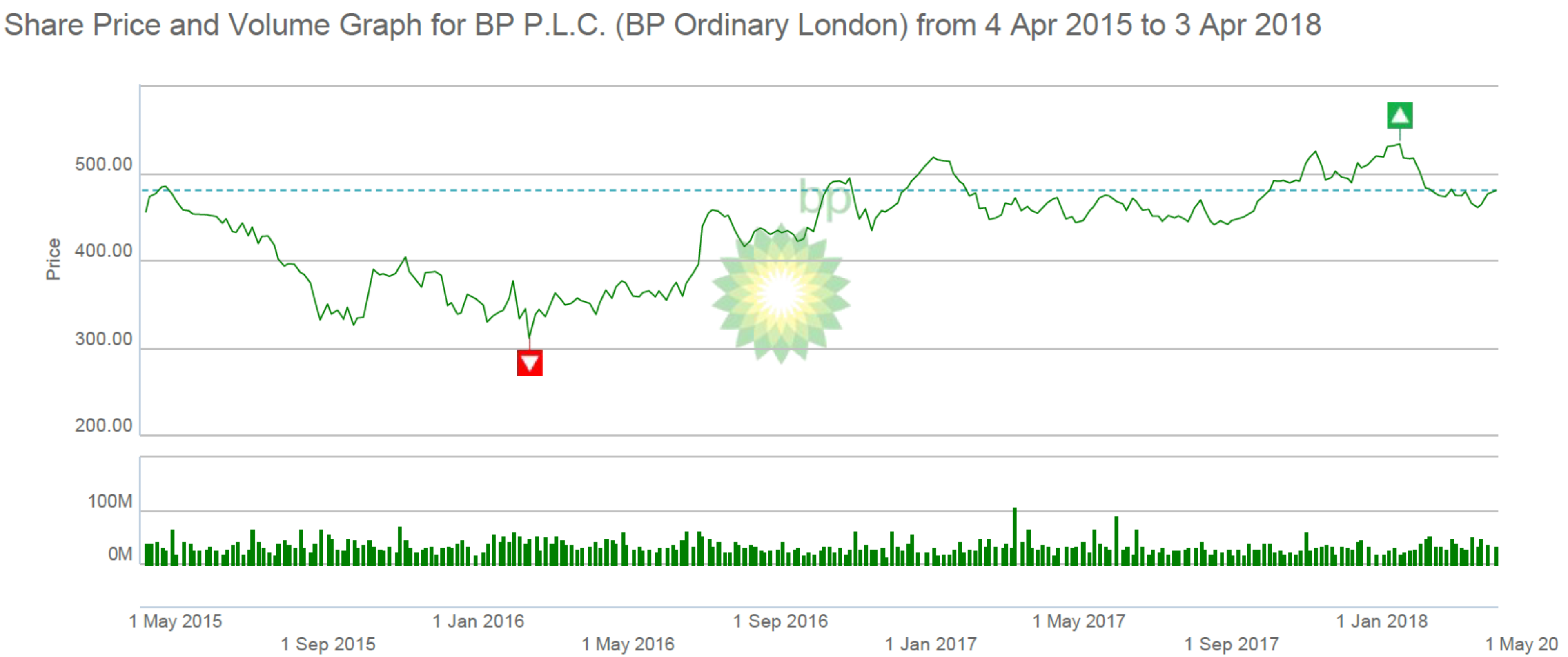
Our downside case assumes a long-term Brent price deck of $50/bl in our NAV analysis plus a potential premium/discount.

Upside/Downside scenarios



Source: Company data, Barclays Research
Note: FY End Dec

Share price determines market valuation



- Share price multiplied by number of shares in issue = market value
- Market value divided by profits gives "price to earnings ratio"
- Potential value can be derived by using multiples and future profit forecasts

Comparison with Peer Groups

Comparative multiples-based valuations

	P/E			EV/EBITDA		
	2017E	2018E	2019E	2017E	2018E	2019E
Russia and FSU						
Gazprom	4.3	3.6	3.4	3.5	2.8	2.8
Lukoil	8.6	5.9	6.2	4.2	3.3	3.4
Novatek	15.0	14.4	9.8	12.3	10.9	11.0
Gazprom Neft	4.9	3.9	4.3	4.4	3.9	4.4
Surgutneftegaz	7.9	4.0	4.8	neg.	neg.	neg.
Tatneft	10.1	8.3	8.1	6.3	5.3	5.2
Rosneft	13.8	8.0	5.2	7.0	5.7	5.0
Transneft	5.8	6.1	5.5	3.9	3.7	3.4
Bashneft	2.6	4.5	3.9	3.5	3.0	2.7
Emerging markets						
Sinopec	12.6	11.4	10.7	4.6	4.2	3.9
CNOOC	14.5	10.4	10.3	5.1	4.3	4.2
PetroChina	61.5	35.1	30.1	6.7	6.0	5.7
Petrobras	20.7	11.7	8.7	6.1	5.1	4.5
ONGC	12.9	10.0	8.6	7.2	5.0	4.3
Developed markets						
Royal Dutch Shell	17.9	14.8	13.6	8.2	5.7	5.4
BP	22.6	15.5	14.2	6.1	5.3	4.9
Chevron	34.2	17.6	18.0	8.9	6.4	6.0
ConocoPhillips	96.2	23.2	22.1	20.7	6.9	6.4
Eni	25.2	17.4	16.8	4.8	4.0	3.8
ExxonMobil	22.1	16.6	17.6	9.6	7.7	7.8
Statoil	17.7	16.5	15.5	4.0	3.6	3.3
Total	14.0	12.6	12.0	6.4	5.3	5.0

Note: Based on prices as of February 5, 2018. Bloomberg consensus estimates are used for foreign companies and Sberbank CIB Investment Research estimates for Russian and FSU companies.

Source: Bloomberg, Sberbank CIB Investment Research

A typical spreadsheet summary of a cashflow model

DCF Valuation	**Projected Free Cash Flow**					
Calendar Years ending December 31,	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**
($ in thousands)						
EBITDA	$8,954	$9,898	$10,941	$12,093	$13,367	$13,367
Less D&A	1,112	1,222	1,343	1,476	1,623	1,623
EBIT	7,842	8,676	9,598	10,617	11,745	11,745
Less: Cash Taxes (35%)	(2,745)	(3,037)	(3,359)	(3,716)	(4,111)	(4,111)
Tax-adjusted EBIT	**5,097**	**5,639**	**6,239**	**6,901**	**7,634**	**7,634**
Pluss: D&A	1,112	1,222	1,343	1,476	1,623	1,623
Less: Capital Expenditures	(1,750)	(1,750)	(1,750)	(1,750)	(1,750)	(1,750)
Less: Change in Net Working Investment	(318)	(350)	(384)	(423)	(465)	(465)
Unlevered Free Cash Flow	**$4,141**	**$4,762**	**$5,447**	**$6,205**	**$7,042**	**$7,042**

$$\$19{,}845 = \frac{\$4{,}141}{(1+.11)^1} \quad \frac{\$4{,}762}{(1+.11)^2} \quad \frac{\$5{,}447}{(1+.11)^3} \quad \frac{\$6{,}205}{(1+.11)^4} \quad \frac{\$7{,}042}{(1+.11)^5}$$

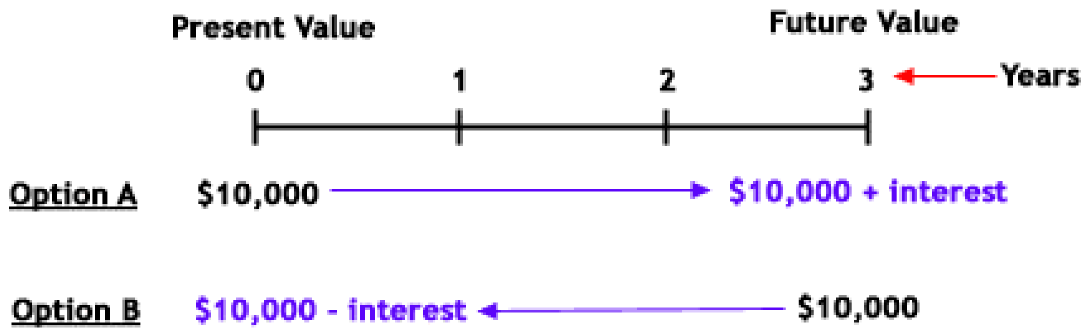
Time Value of Money

- Money available at the present time is **worth** more than the **same** amount in the **future** due to its potential earning capacity.

- This **core** principle of finance holds that, provided money can earn interest, any amount of money is **worth** more the sooner it is received

- Equally, money available now can buy more than a similar amount of money available in the future because **inflation** erodes the value of money over time

Time Value of Money Example



- If you had $10,000 today, you could earn interest on it
- Its future value is $10,000 x (1 + interest rate)$^{\text{No. of years}}$
- If interest rate is 5%, then $10,000 in 3 years is worth
  - $10,000 x (1+.05)^3 = $11,576
- As a result, $10,000 in 3 years is not worth $10,000 now
  - $10,000 / (1+.05)^3 = $8,638
- Let's look at an example

Impact of inflation

- I have $100
- A bar of chocolate costs $1
- Inflation is 5%
- In Year 1 I can buy 100 bars of chocolate
- In Year 2 the cost of a bar of chocolate has risen to $1.05

Year	Money	Cost of chocolate	No. of Bars (whole)
1	$100	1	100
2	$100	1.05	95
3	$100	1.102	91
4	$100	1.158	86
5	$100	1.216	82
6	$100	1.276	78

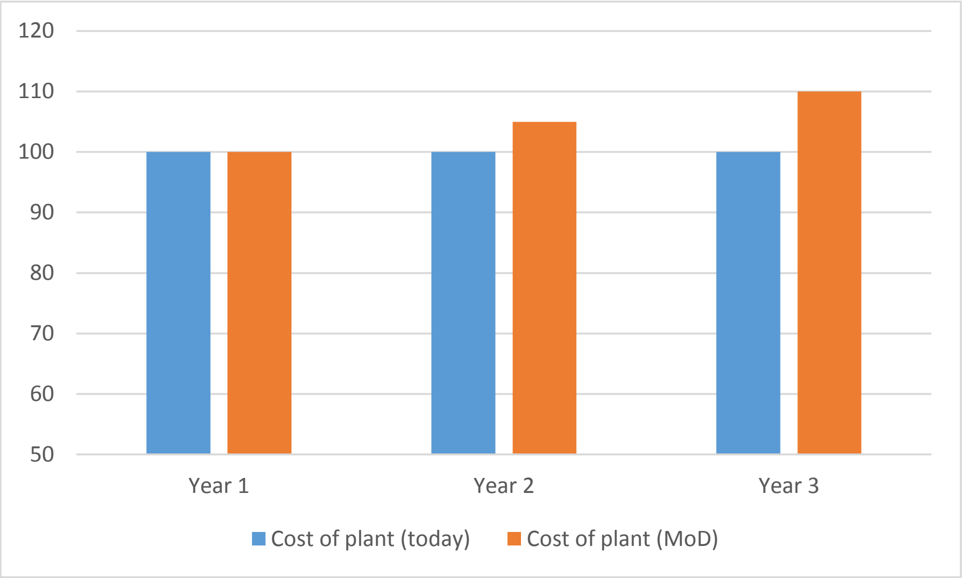
Inflation and interest rates

- I have $500
- Inflation is running at 4% per annum, and the interest rate is 5%
- I want to purchase printer ink, which costs $5 per cartridge
- How many fewer cartridges can I buy in 7 years time than now if I just keep my $500 in my wallet?
- If I put my $500 in an interest bearing account, how many cartridges could I buy in 4 years time?

Real and Nominal Figures

- Nominal cashflows include the impact of inflation
- They are called Money of the Day (MoD) because they reflect the actual worth in a certain year
- If we were forecasting the cost of a project, for example, we would need to add inflation to each year as we moved across the time horizon
- This is relevant for multi-year developments when parts are being purchased over time

Nominal Costs Example



	Year 1	Year 2	Year 3	Total
Cost of plant (today)	100	100	100	300
Cost of plant (MoD)	100	105	110	315

- Costs will rise over time because of inflation (in this example 5% per annum)

Using “Real” figures makes life easier

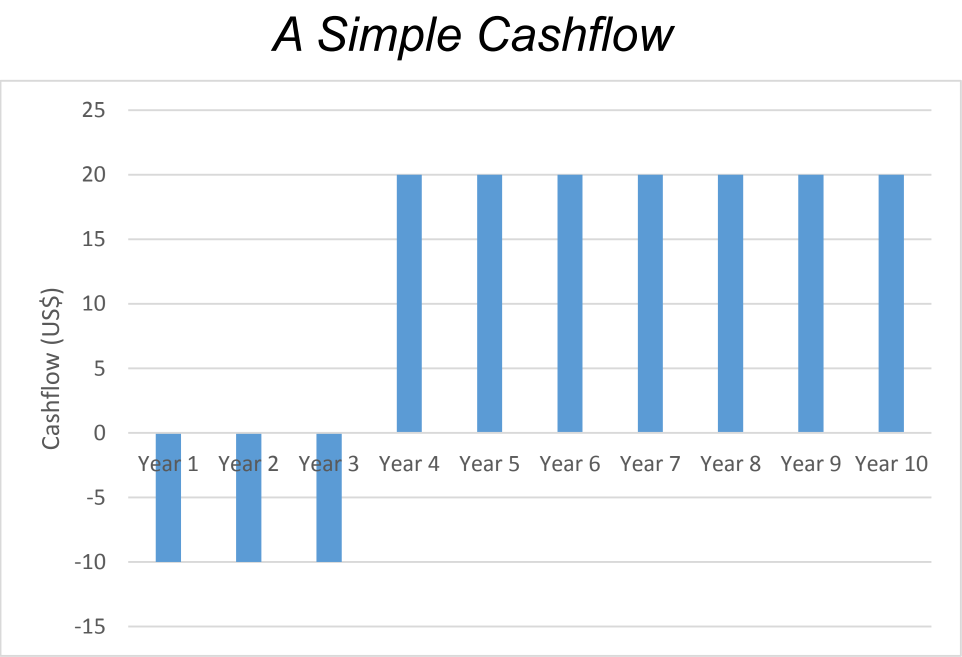
- When making assumptions in nominal, every figure needs to take an inflation assumption into account
- This can make things very complex
- To make life easier, we can just assume that our model is in “today’s money” – otherwise known as “in real terms”
- Generally, we would define all the figures as being in (e.g.) US$2020
- All figures in the cashflow will be lower as a result, and so it is important to define how the model is considering inflation

Real and Nominal Figures

- Question 1
  - The cost of a plant is $500mm spent equally over 5 years in real (2020) terms
  - Inflation throughout the period is forecast to be 2.5% per annum
  - What is the expenditure on the plant in nominal terms in Year 5 and what is the total nominal cost?

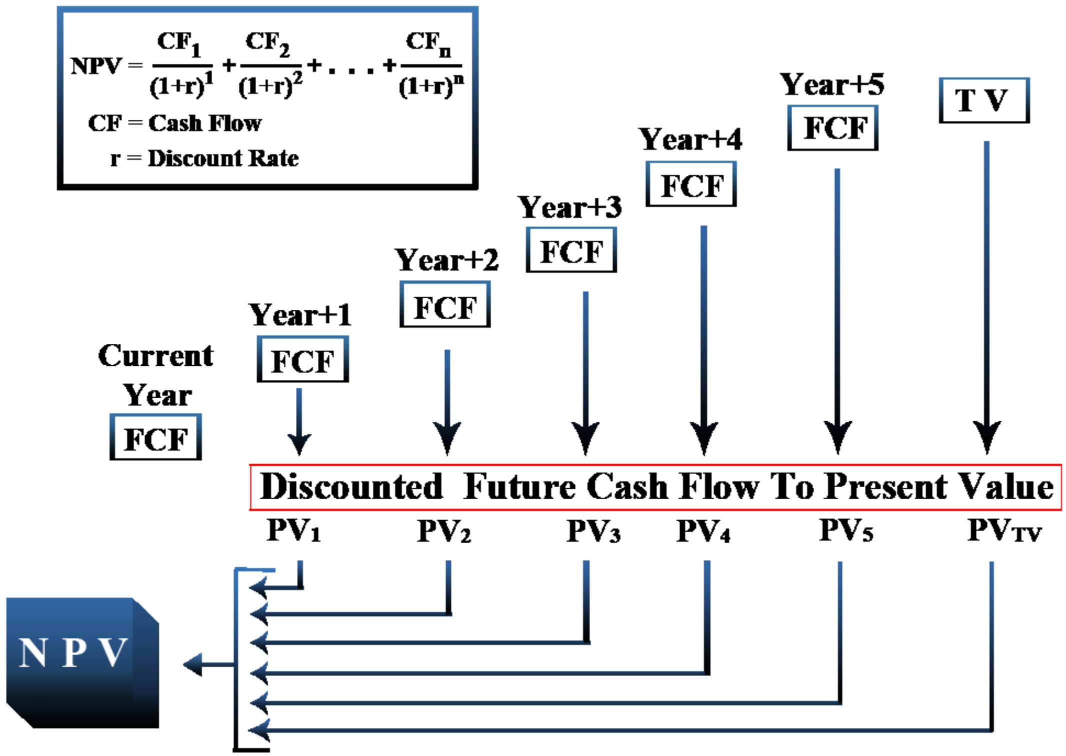
- Question 2
  - We are assuming that the oil price is $30 in real (2020) terms
  - Inflation is assumed to be 2% per annum
  - What is the real oil price in Year 5?
  - What is the nominal price in Year 5?
  - What is the real price in Year 5 if we assume that the oil price will rise at 1% above inflation?

Discounted Cashflow



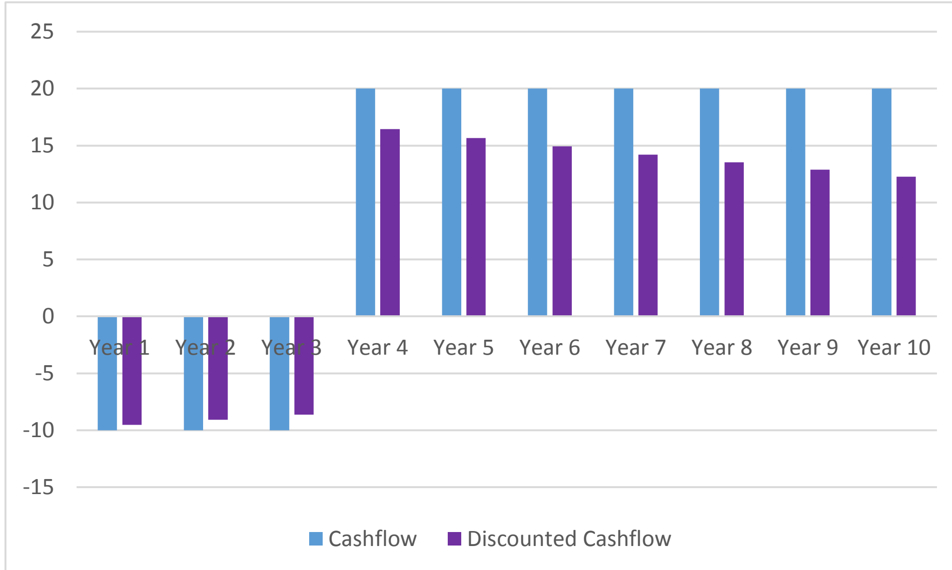
- In Year 0 (today), I decide to invest $30mm over 3 years in a plant that will run for 7 years, generating $20mm per year
- The plant will then be dumped
- What is the value (worth) of this investment in today's terms?

The DCF Calculation as a foundation



- Management thought process is encapsulated in the DCF model
  - Key assumptions include price, cost, tax, long-term outlook, short-term cashflow and the value of money
- Management must ensure at all times that the combined value of their assets remains NPV positive, and should aim to maximise the return on their assets

Discounted Cashflow Example



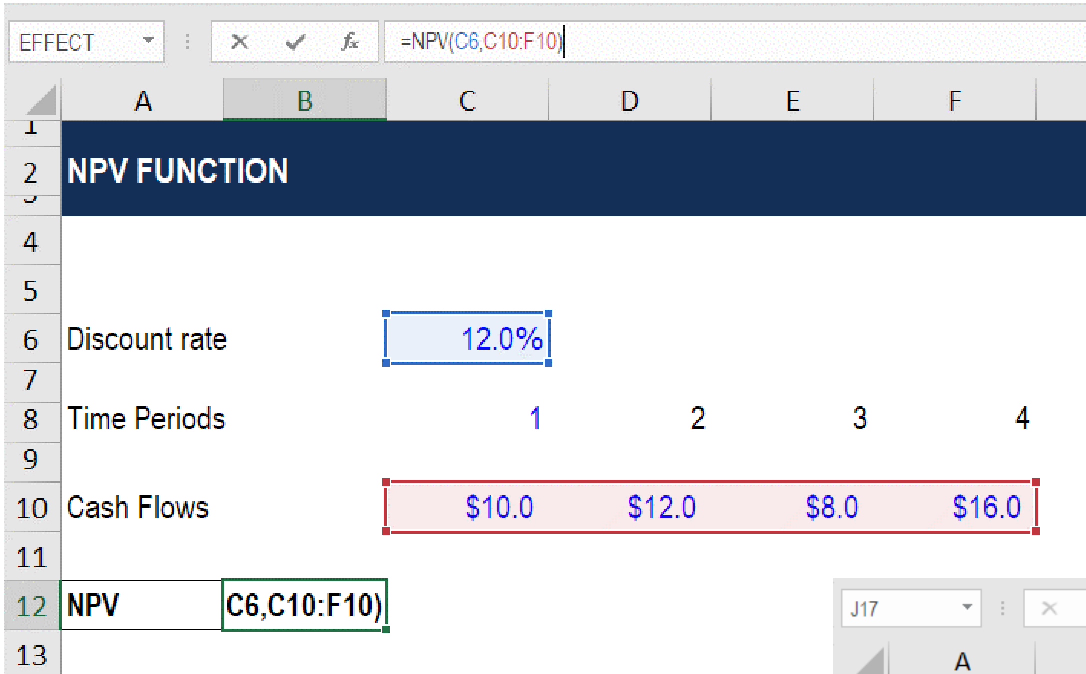
	Today	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Cashflow	0	-10	-10	-10	20	20	20	20	20	20	20
Discount factor	1	1.05	1.10	1.16	1.22	1.28	1.34	1.41	1.48	1.55	1.63
Discounted Cashflow	0	-9.52	-9.07	-8.64	16.45	15.67	14.92	14.21	13.54	12.89	12.28
Total Value	72.74										

- The further away that money is earned (or spent) the less worth (value) it has today
- We discount future cashflow by a factor reflecting the other options we had for using the initial funds
- If the total sum of negative and positive cashflow is positive then the investment is worth making

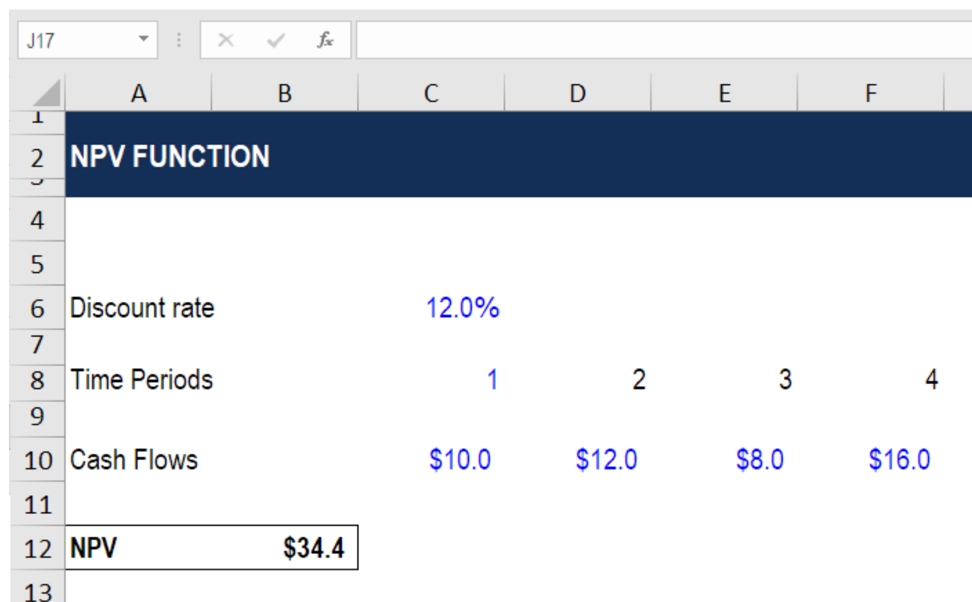
A Good Explanation from Harvard

- https://hbr.org/2014/11/a-refresher-on-net-present-value

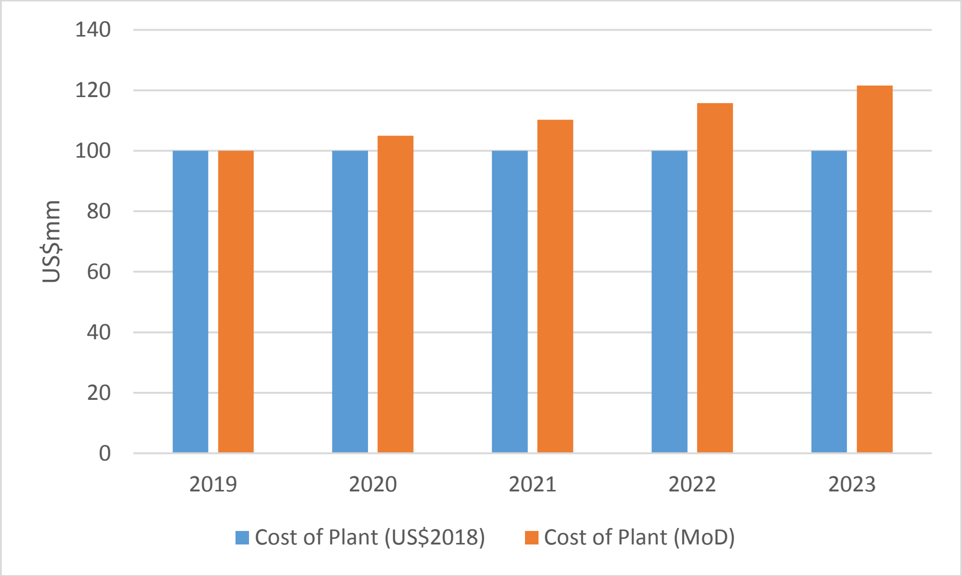
Functionality in Excel



- The NPV function in Excel makes life very easy
- =NPV(discount rate, range of net cashflow)



Real vs Nominal Cashflow and NPV



	2019	2020	2021	2022	2023
Cost of Plant (US$2018)	100	100	100	100	100
Cost of Plant (MoD)	100	105	110	116	122
NPV (Real)	433				
NPV (MoD)	476				

- To make our lives easier, all our modelling will be carried out in real terms
- Our expectations of return should therefore be lower

Construct a simple cashflow model

- All figures in US$2019 (Real)
- Capital costs - $600 over 3 years
- Revenues – start in year 4, $100 per year from year 4 to year 20
- Operating costs - $20 per year starting in year 4 until end of operations
- Discount rate 10%

Starting to construct a real project cashflow model

- Revenues
  - Production of energy
  - Price received for energy supply
- Cost of Development (Capex)
  - How much will it cost to put the necessary infrastructure in place?
- Cost of Operations (Opex)
  - How much will it cost to run the infrastructure and produce energy
  - How much will it cost to transport it to market?

What will the government get out of it?

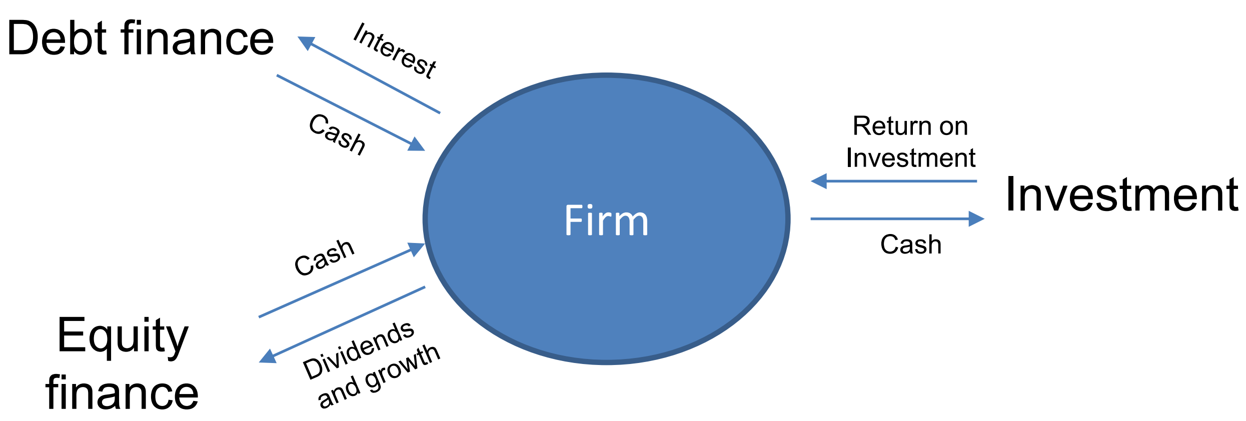
- Operating taxes
  - Royalty
  - Export tax
  - Other social taxes
- Profit Tax
  - Depreciation is a key assumption
- Alternative forms of taxation
  - Production Sharing Agreement

Time to talk about project parameters

- Investment costs
  - Cost of up-front investment
  - Timescale
- Production
  - How much energy is produced?
  - What is the output profile?
- Prices
  - Price of energy sales
  - Price of energy and other inputs
- Operating Costs
  - Cost to run the asset
  - Fuel input costs
  - Transport costs
  - Taxes

The Discount Rate

- A firm is like a pool of cash that has been financed from two sources – debt from banks and equity capital from shareholders
- Both sources of financing demand a return for providing cash
- Companies therefore need to at least recuperate their Weighted Average Cost of Capital from each investment they make



Weighted Average Cost of Capital

- **WACC = [E/V * Re] + [D/V * Rd * (1-Tc)]**

- E = firm's equity, D = firm's debt, V = total value of firm's financing (V = E+D)

- Re = cost of equity, Rd = cost of debt

- Tc = corporate tax rate (firms can claim cost of interest against tax)

Cost of Debt

- How much does it cost to borrow money?

- Government borrowing rate (LIBOR)
  - US$ 1.75%
  - UK£ 0.70%

- Corporate borrowing rate (LIBOR + X%)
  - Depends on loan amount and credit worthiness of borrower
  - Ratings agencies provide assessments used by lenders

- Corporate bond rate (latest Eurobond offering)
  - Gazprom 2017 Eurobond – 4.25%
  - BP 2017 US$ bond – 2.24%

- Interest payments are allowable for tax
  - Cost of debt = Interest rate x (1-tax rate)

Credit ratings impact the cost of debt, as well as investor preceptions

Grade	Moody's Long term	Moody's Short term	S&P Long term	S&P Short term	Fitch Long term	Fitch Short term	
INVESTMENT GRADE	Aaa	Prime 1	AAA	A–1+	AAA	F1+	HIGHEST
INVESTMENT GRADE	Aa1	Prime 1	AA+	A–1+	AA+	F1+	
INVESTMENT GRADE	Aa2	Prime 1	AA	A–1+	AA	F1+	
INVESTMENT GRADE	Aa3	Prime 1	AA–	A–1+	AA–	F1+	
INVESTMENT GRADE	A1	Prime 1	A+	A–1+ / A–1	A+	F1+ / F1	
INVESTMENT GRADE	A2	Prime 1 / Prime 2	A	A–1	A	F1	
INVESTMENT GRADE	A3	Prime 1 / Prime 2	A–	A–1 / A–2	A–	F1 / F2	
INVESTMENT GRADE	Baa1	Prime 2	BBB+	A–2	BBB+	F2	
INVESTMENT GRADE	Baa2	Prime 2 / Prime 3	BBB	A–2 / A–3	BBB	F2 / F3	
INVESTMENT GRADE	Baa3	Prime 3	BBB–	A–3	BBB–	F2 / F3	
NON-INVESTMENT GRADE	Ba1	Not prime	BB+	B	BB+	B	
NON-INVESTMENT GRADE	Ba2	Not prime	BB	B	BB	B	
NON-INVESTMENT GRADE	Ba3	Not prime	BB–	B	BB–	B	
NON-INVESTMENT GRADE	B1	Not prime	B+	C	B+	B	
NON-INVESTMENT GRADE	B2	Not prime	B	C	B	B	
NON-INVESTMENT GRADE	B3	Not prime	B–	C	B–	B	
NON-INVESTMENT GRADE	Caa	Not prime	CCC	C	CCC	C	
NON-INVESTMENT GRADE	Ca	Not prime	CC	C	CC	C	
NON-INVESTMENT GRADE	C	Not prime	C	C	C	C	
NON-INVESTMENT GRADE			D	D	D	D	LOWEST

Source: The Association of Corporate Treasurers

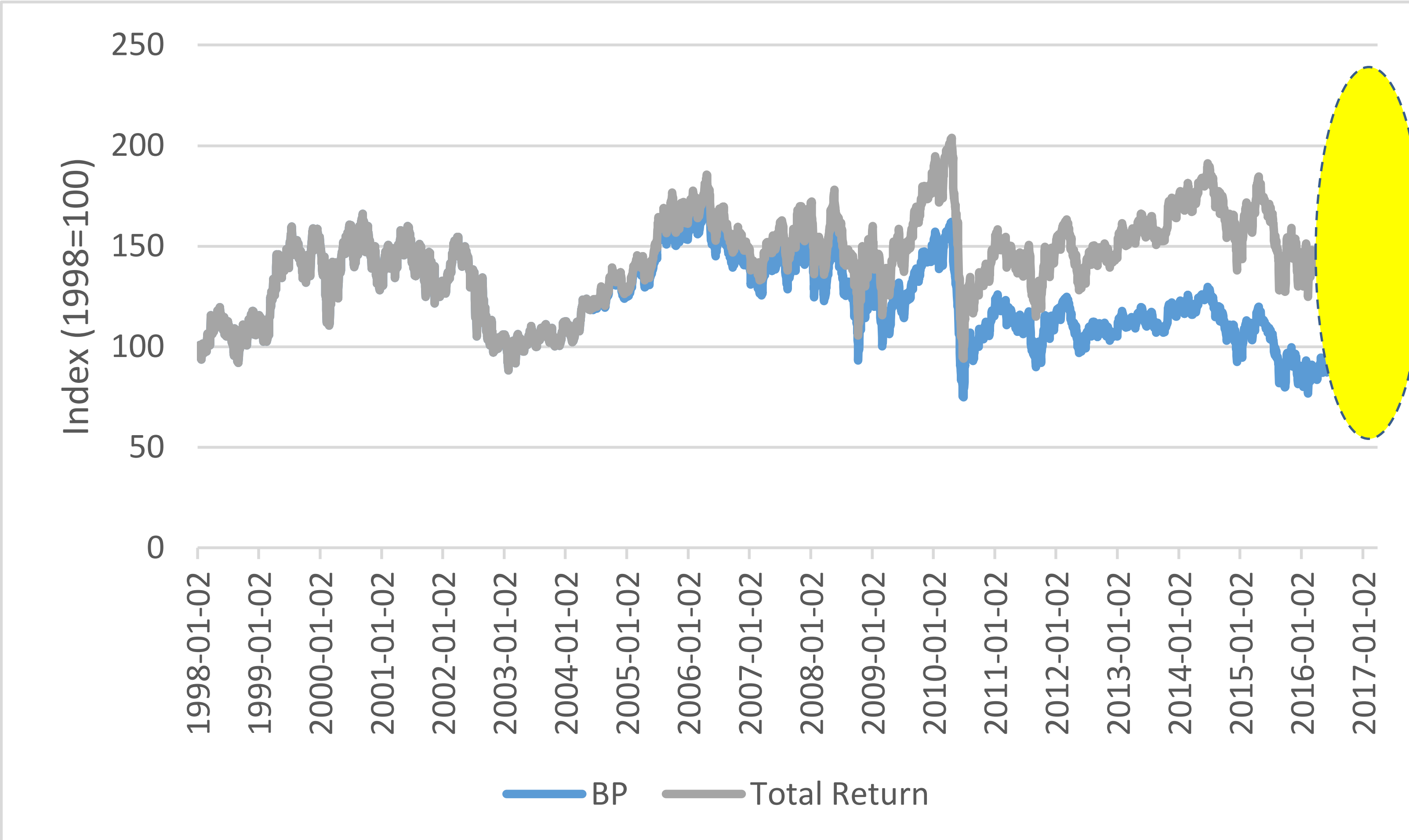
Cost of Equity

- What constitutes a return for a shareholder?
  - Dividends
  - Capital Growth
  - Total Shareholder Return

- Average cost of equity
  - The minimum acceptable return – the risk free rate
  - The premium for investing in the equity market (the return on the equity market compared to the risk free rate)
  - The specific premium for each company (the Beta) – how different is it to the market
    - Beta value is a measure of specific risk for a company – 1 is the market average
    - BP – 0.99; ExxonMobil - 0.84
    - Sound Energy – 2.83; Chesapeake – 2.68

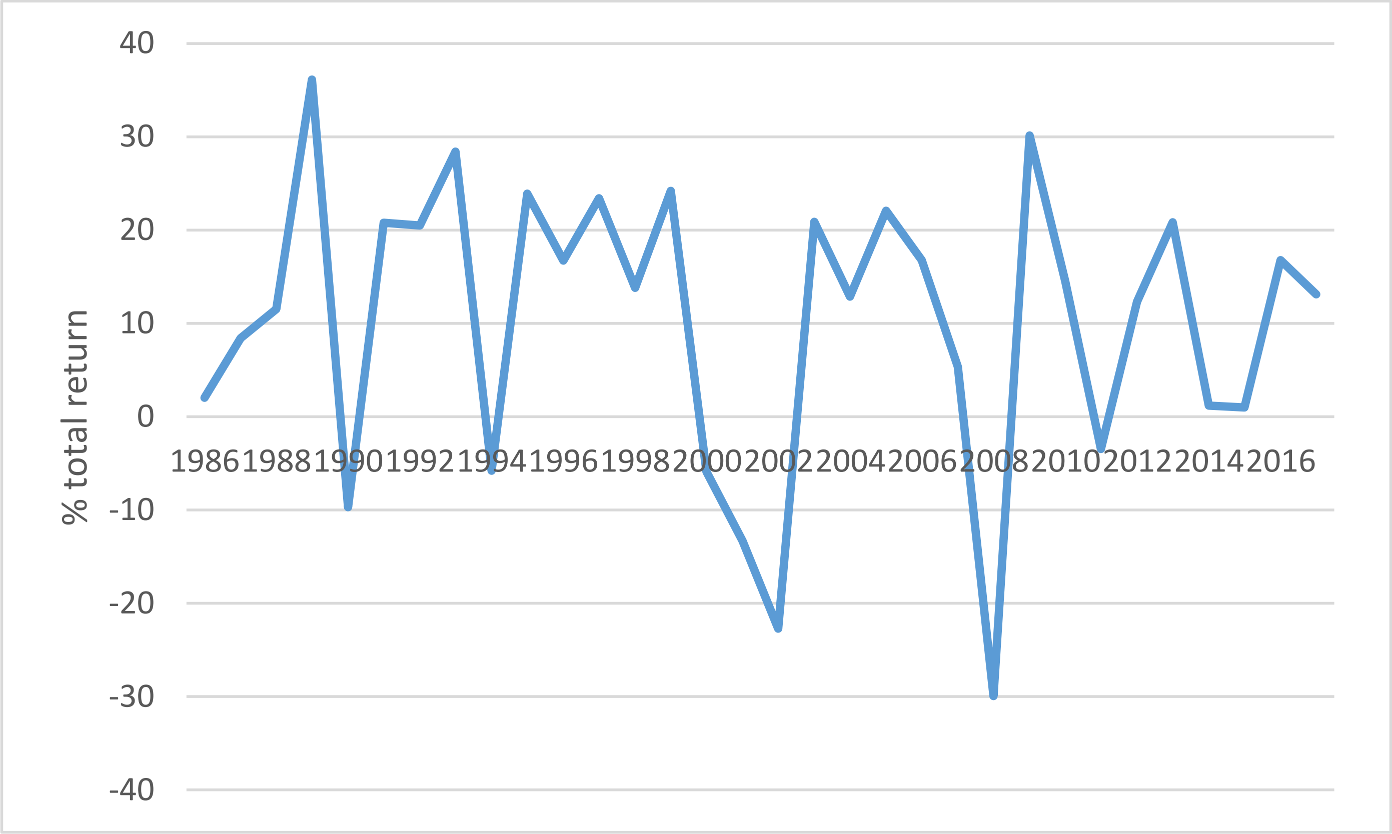
- Risk free rate (LIBOR) + (Beta for a specific company * the equity market premium)

Total return to shareholders



- Almost no gain in share price terms over almost 20 years
- Shareholders doubled their money when dividends and other incentives are included

Total return on FTSE World Index



- Average return over 10 years = 6.86%
- Average return over 5 years = 9.85%
- Average return over 1 year = 12.0%
- Average return over 20 years = 10.53%

The DCF Calculation as a foundation – WACC concept

Weighted average cost of capital is corporate "interest rate"

2.

$$WACC = \frac{E}{D+E}(r_e) + \frac{D}{D+E}(r_d)(1-t)$$

Where:
E = market value of equity
D = market value of debt
r_e = cost of equity
r_d = cost of debt
t = corporate tax rate

WACC is the cost to a company of financing the capital for a project, including debt and equity

Cost of debt = average interest rate for company

Cost of equity is theoretical return to investors in the company

Cost of Equity = Risk free rate + (Beta(Market return – Risk free rate))*

Essentially, how much return would an investor expect relative to putting his money with US Treasury stock, or in the stock market

WACC Calculation

BP

- Debt/Equity – 30:70
- Equity Market return – 10.53%
- Risk free rate – 1.75%
- Cost of Equity
- 1.75 + (0.99 x (10.53 – 1.75)) = 1.75 + 8.69 = 10.44

- Cost of Debt – 2.24% x (1-0.2) = 1.79%

- WACC calculation

  (10.44*0.7)+(1.79*0.3)

  =7.31% + 0.54%

  =7.85%

WACC Calculation

Sound Energy

- Debt/Equity – 50:50
- Equity Market return – 10.53%
- Risk free rate – 1.75%
- Cost of Equity
- 1.75 + (2.83 x (10.53 – 1.75)) = 1.75 + 25.85 = 26.60

- Cost of Debt – 5.75% (LIBOR+4%) x (1-0.2) = 4.60%

- WACC calculation

  (26.60*0.5)+(4.60*0.5)

  =13.3% + 2.3%

  =15.6%

WACC Questions

- Calculate the WACC based on the following assumptions:

- General
  - Risk-free rate – 1.5%
  - Equity market return – 8%
  - Corporate tax rate – 25%

- Specific
  - Company 1: Beta – 0.85, Interest rate on Debt – 3.5%, Share of Equity – 40%
  - Company 2: Beta – 1.75, Interest rate on Debt – 5%, Share of Equity – 30%
  - Company 3: Beta – 3.0, Interest rate on Debt – 7.5%, Share of Equity – 70%

- Double the Beta of Company 1. What happens to the WACC?
  - Do the same for company 3. What happens?

- In general, what is the optimal financing strategy for reducing WACC?
  - Can you think why it may or may not be possible to achieve this?

Terminal Value Calculation (1)

- Two methodologies
  - Perpetual Growth Method
  - Exit Multiple Method

- Perpetual Growth Method
  - TV = [FCFn x (1+g)] / (WACC-g)

  - TV = terminal value
  - G = perpetual growth rate of FCF
  - WACC = Weighted average cost of capital

- Generally used in academia rather than business
  - Need to assume “G”

Terminal Value Calculation (2)

- Exit Multiple Method
  - Preferred by industry as it compares a value of a business or asset with an observation in the market
  - The multiple tends to be the average for the industry or a peer group
  - The EV/EBITDA multiple is the most common
- The Exit Multiple Formula
  - TV=Financial Metric (EBITDA) x Trading Multiple (EV/EBITDA)
- Assume Terminal Value in final year +1, then discount with rest of cashflow model

Terminal Value Calculation (3)

- Looking for multiples

Comparative multiples-based valuations

	P/E			EV/EBITDA		
	2017E	2018E	2019E	2017E	2018E	2019E
Russia and FSU						
Gazprom	4.3	3.6	3.4	3.5	2.8	2.8
Lukoil	8.6	5.9	6.2	4.2	3.3	3.4
Novatek	15.0	14.4	9.8	12.3	10.9	11.0
Gazprom Neft	4.9	3.9	4.3	4.4	3.9	4.4
Surgutneftegaz	7.9	4.0	4.8	neg.	neg.	neg.
Tatneft	10.1	8.3	8.1	6.3	5.3	5.2
Rosneft	13.8	8.0	5.2	7.0	5.7	5.0
Transneft	5.8	6.1	5.5	3.9	3.7	3.4
Bashneft	2.6	4.5	3.9	3.5	3.0	2.7
Emerging markets						
Sinopec	12.6	11.4	10.7	4.6	4.2	3.9
CNOOC	14.5	10.4	10.3	5.1	4.3	4.2
PetroChina	61.5	35.1	30.1	6.7	6.0	5.7
Petrobras	20.7	11.7	8.7	6.1	5.1	4.5
ONGC	12.9	10.0	8.6	7.2	5.0	4.3
Developed markets						
Royal Dutch Shell	17.9	14.8	13.6	8.2	5.7	5.4
BP	22.6	15.5	14.2	6.1	5.3	4.9
Chevron	34.2	17.6	18.0	8.9	6.4	6.0
ConocoPhillips	96.2	23.2	22.1	20.7	6.9	6.4
Eni	25.2	17.4	16.8	4.8	4.0	3.8
ExxonMobil	22.1	16.6	17.6	9.6	7.7	7.8
Statoil	17.7	16.5	15.5	4.0	3.6	3.3
Total	14.0	12.6	12.0	6.4	5.3	5.0

Note: Based on prices as of February 5, 2018. Bloomberg consensus estimates are used for foreign companies and Sberbank CIB Investment Research estimates for Russian and FSU companies.

Source: Bloomberg, Sberbank CIB Investment Research

Average: 4.9 (Oil only)

Average: 5.9

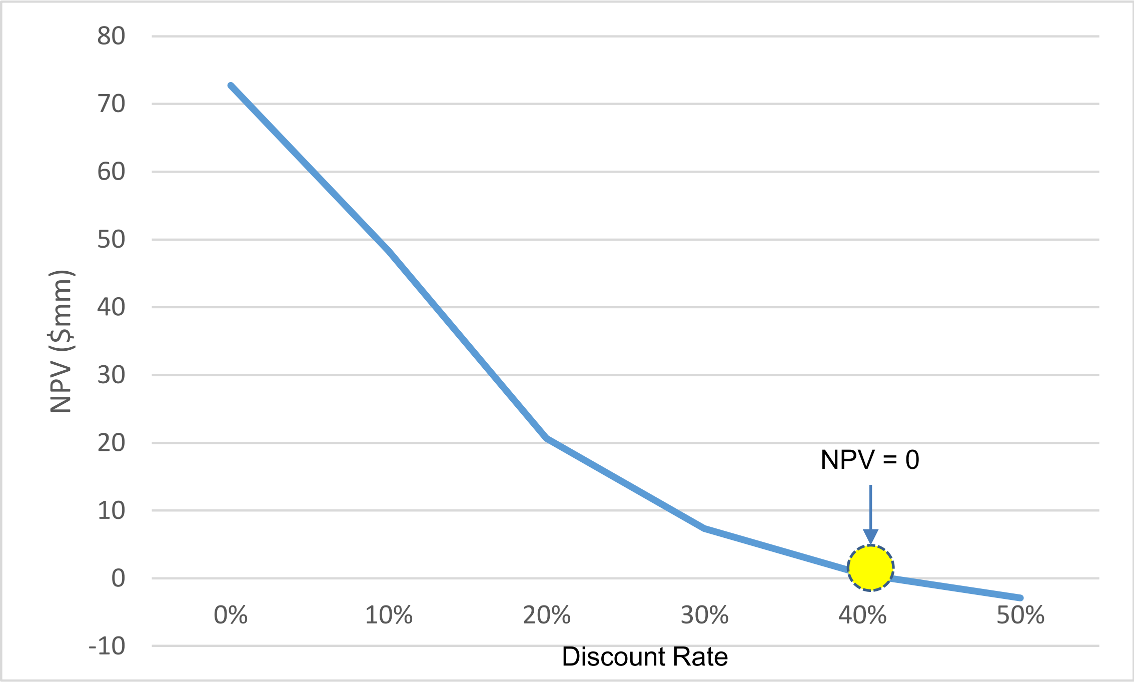
Average: 8.6

Internal Rate of Return

- To calculate a NPV, we have to use a discount rate
- This rate is set by calculating the cost of capital, based on the expected rate of return expected by debt and equity investors
- But how high could this expected rate go before the NPV equals zero?
- This figure tells us the Internal Rate of Return (IRR) of the project
  - When the NPV is zero, it means that all the capital is repaid plus a certain level of return
  - As long as the IRR is higher than our discount rate, then the project will have a positive NPV and as reasonable rate of return

Establishing the IRR of a project cashflow

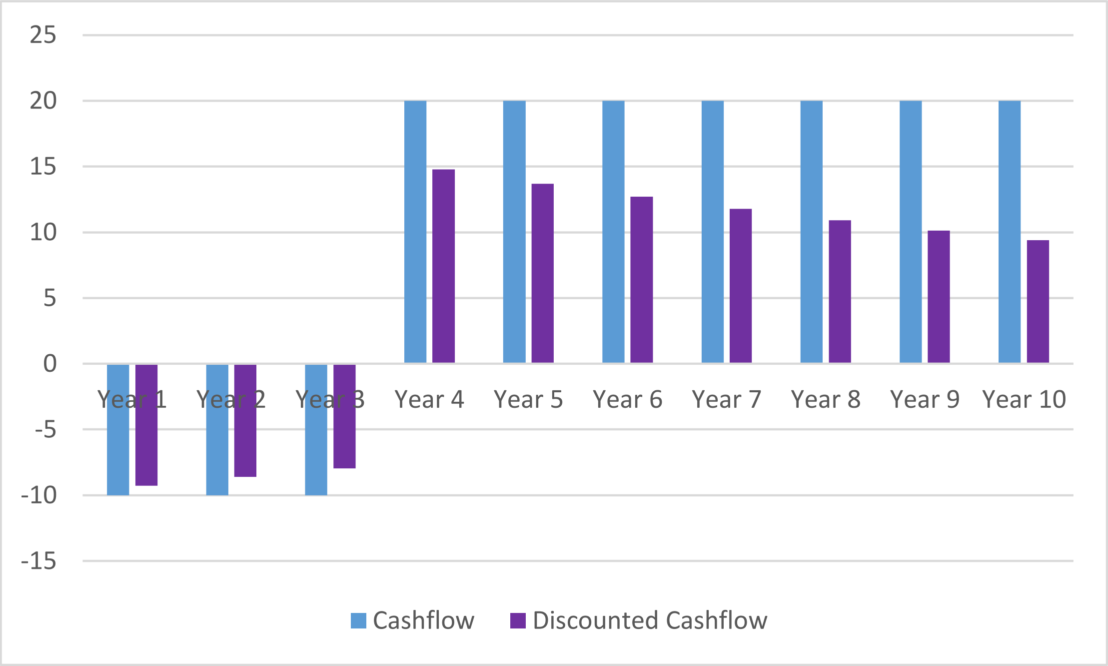
	Today	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Cashflow	0	-10	-10	-10	20	20	20	20	20	20	20
Discount factor	1	1.08	1.16	1.25	1.35	1.46	1.57	1.70	1.83	1.97	2.13
Discounted Cashflow	0	-9.27	-8.60	-7.97	14.78	13.71	12.71	11.78	10.93	10.13	9.39
Total Value	57.59										
Discount Rate	7.85%										
IRR	41%										



Payback

- How long does it take to recover the initial investment
- Measured in years (usually) but can be months for very rapid projects
- Can be calculated in simple or discounted terms
  - In other words either taking into account the time value of money or not

Calculating Payback



- US$30mm invested over three years
- Simple payback – US$30mm recovered after 1.5 years
- Discounted payback - $26mm recovered after 2 years

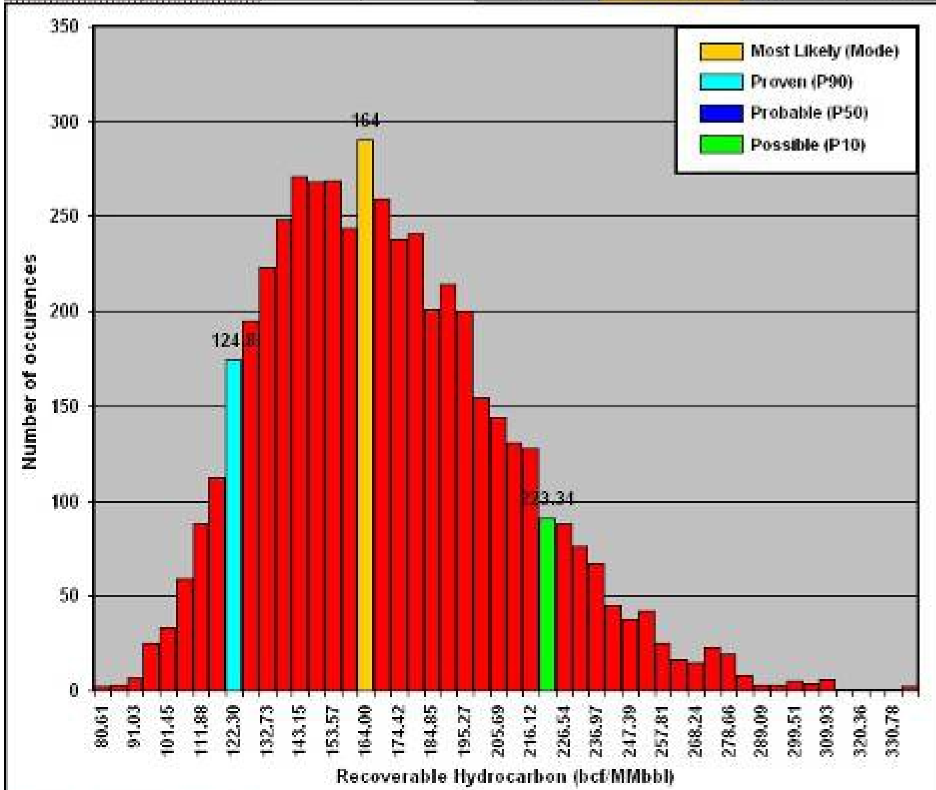
Analysis to Support the Decision to drill an exploration well

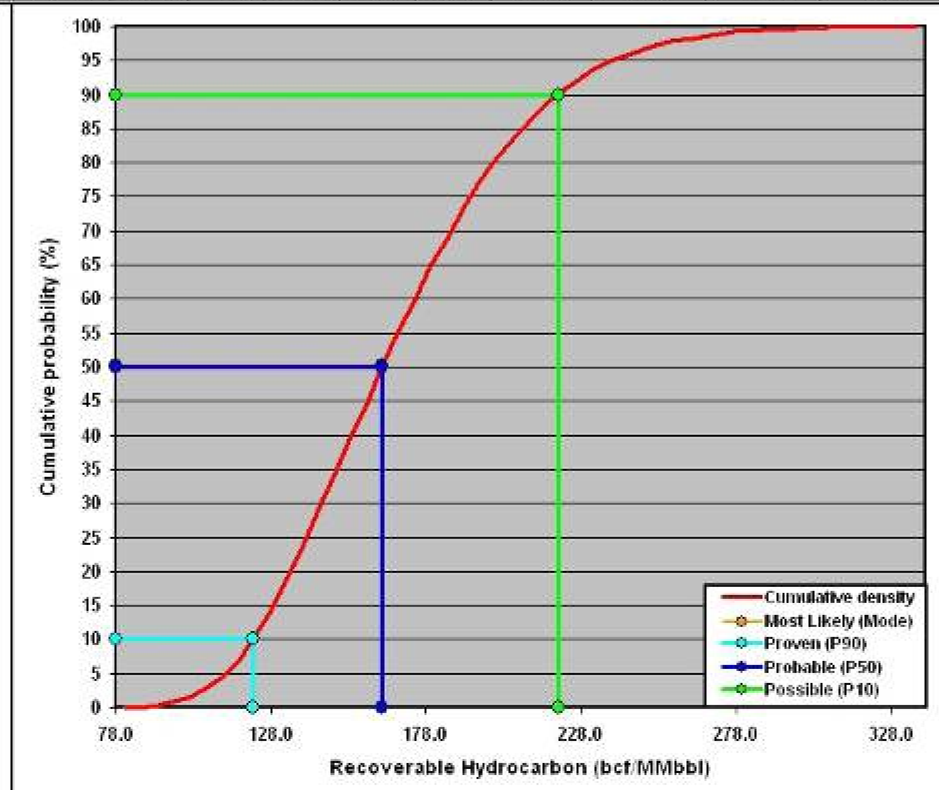
- **Geologists/Geophysicists:**
  - Interpret Seismic data and assess reservoir size probability distribution.
  - Assess the probability of source, reservoir and trap.
- **Reservoir Engineer:**
  - Assess the recoverable reserves and reservoir properties for the 90%,50% and 10% cases.
  - Assess the number of production wells required.
  - Develop annual production profile for the life of the field.
- **Facilities Engineer:**
  - Creates conceptual design for min, mean and max cases with costing and cost phasing.
- **Petroleum Economist:**
  - Models the cashflow of the three reserve cases including tax or Production sharing effects. Derives the Net Present Value of Cashflows, the Internal rate of return and other metrics.
  - Integrates the NPV's over the reserve distribution range to derive the Expected Present value.
  - Performs decision tree analysis based on the probability of the exploration well being successful.
  - Presents the investment case to management.

Create a theoretical cashflow based on assumptions known to date

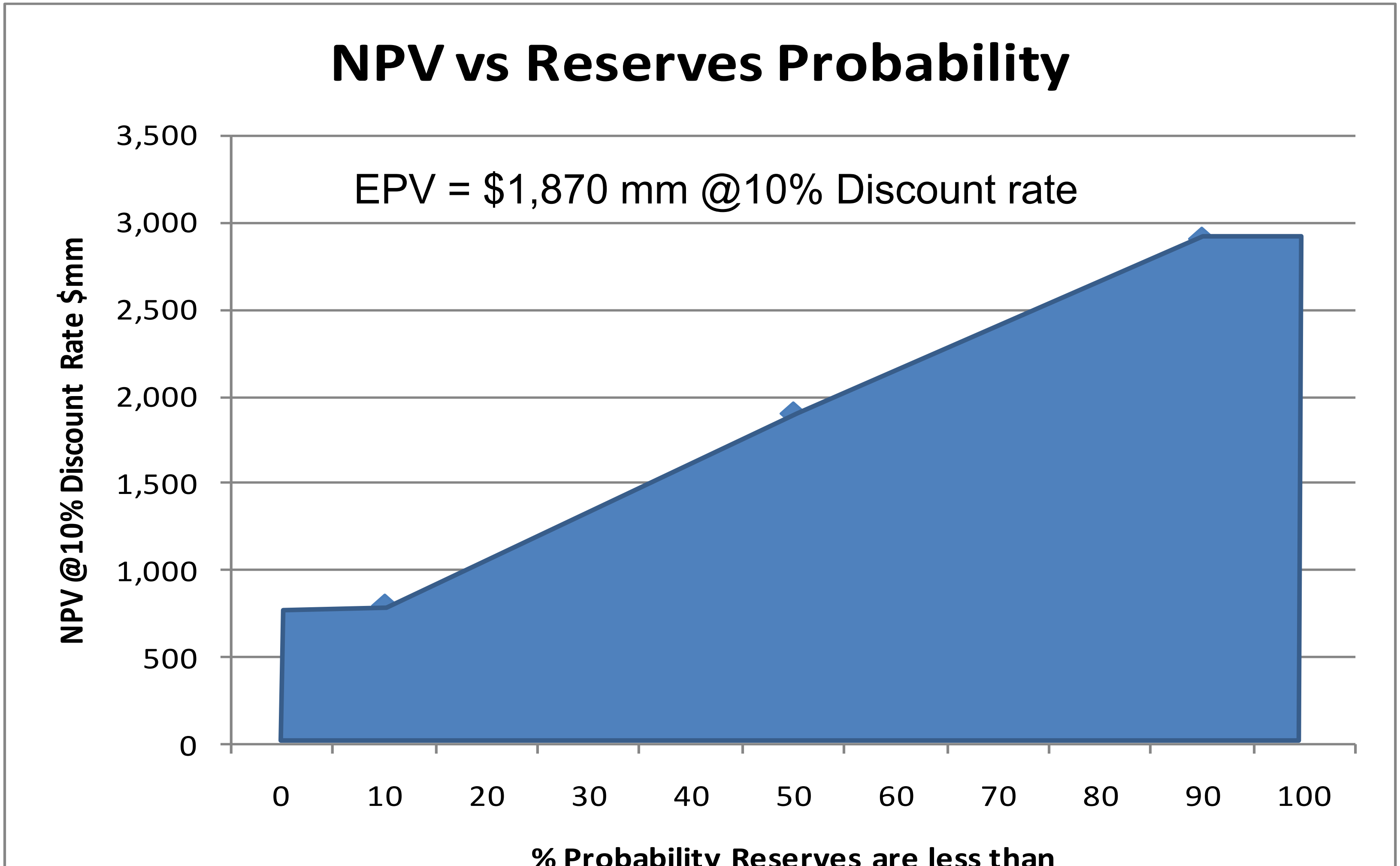
Monte Carlo reserve simulation: results and input parameter summary

Prospect Name	Modelling and structural parameters			Statistics	Recoverable hydrocarbon (bcf/MMbbl)	Volumetric parameters				Petrophyisical parameters				PVT parameters			Field development parameters
	Number of Iterations	Reservoir Type	Trap Type			OWC/GWC depth (m)	Reservoir thickness (m)	Reservoir area (km^2)	GRV (10^6 m^3)	Φ (%)	Sw (%)	S_{hc} (%)	Area N/G	Reservoir Pressure (MPa)	Reservoir Temperature (°C)	Expansion Factor (Sm^3/Rm^3)	Recovery factor
M11-1 Preliminary results	5000	GAS	Simple Layer	Minimum	78.13	2800.01	18.25	8.002	148.12	9.52	20.15	60.30	1.00	46.08	97.00	322.00	0.604
				Most Likely	164.00	2803.41	25.29	8.070	224.85	12.23	30.15	69.85	1.00	46.08	97.00	322.00	0.704
				Maximum	338.45	2849.96	39.77	11.171	412.92	14.09	39.70	79.85	1.00	46.08	97.00	322.00	0.849
				P90	124.80	2804.86	21.79	8.158	193.22	10.66	24.55	64.52	1.00	46.08	97.00	322.00	0.650
				P50	166.48	2824.61	27.01	8.947	245.14	12.02	29.97	70.03	1.00	46.08	97.00	322.00	0.714
				P10	223.34	2844.68	34.13	10.192	315.06	13.19	35.48	75.45	1.00	46.08	97.00	322.00	0.790



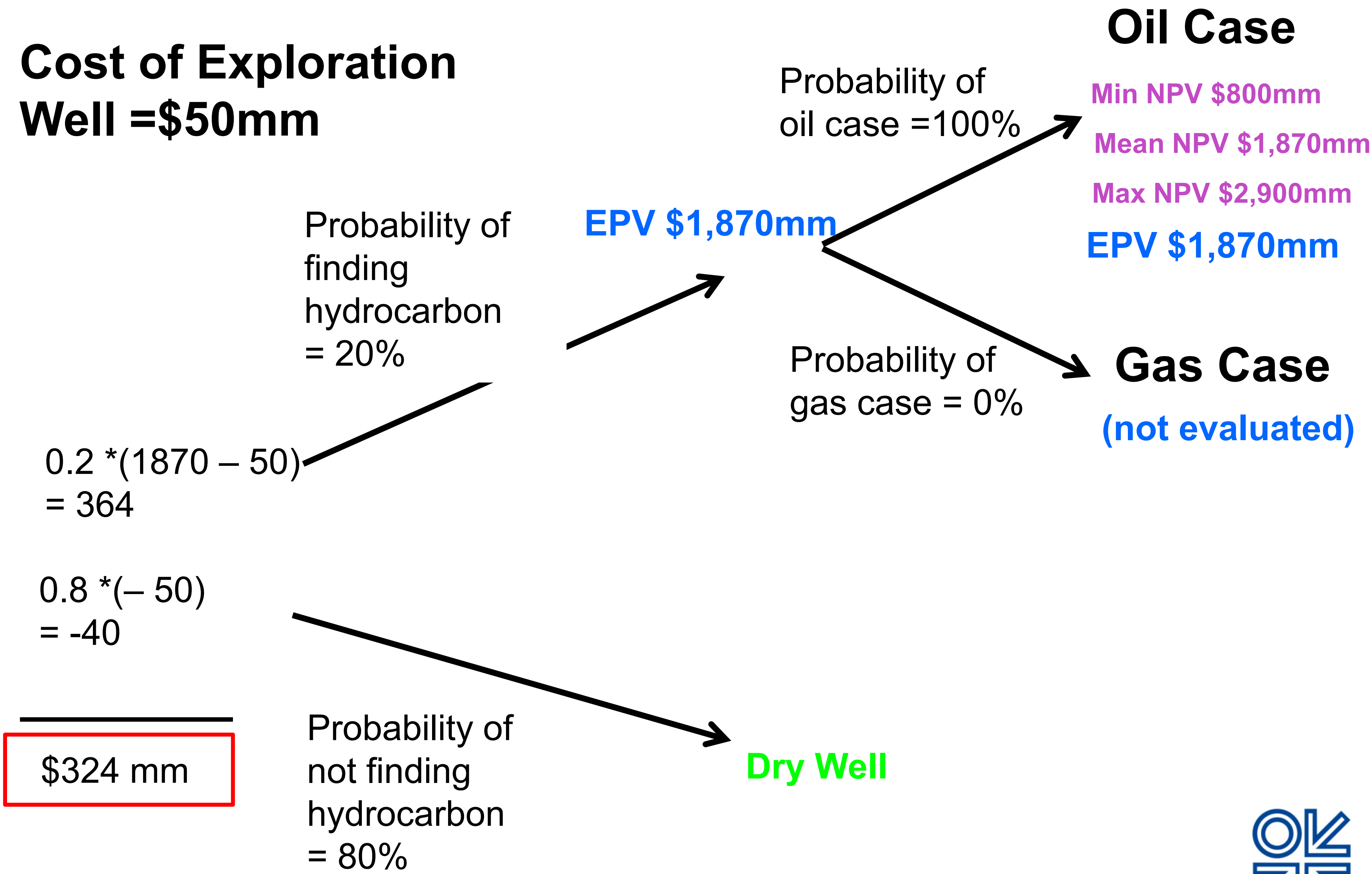


At exploration stage add risk to calculate an Expected Present Value (integration over range of reserves uncertainty)



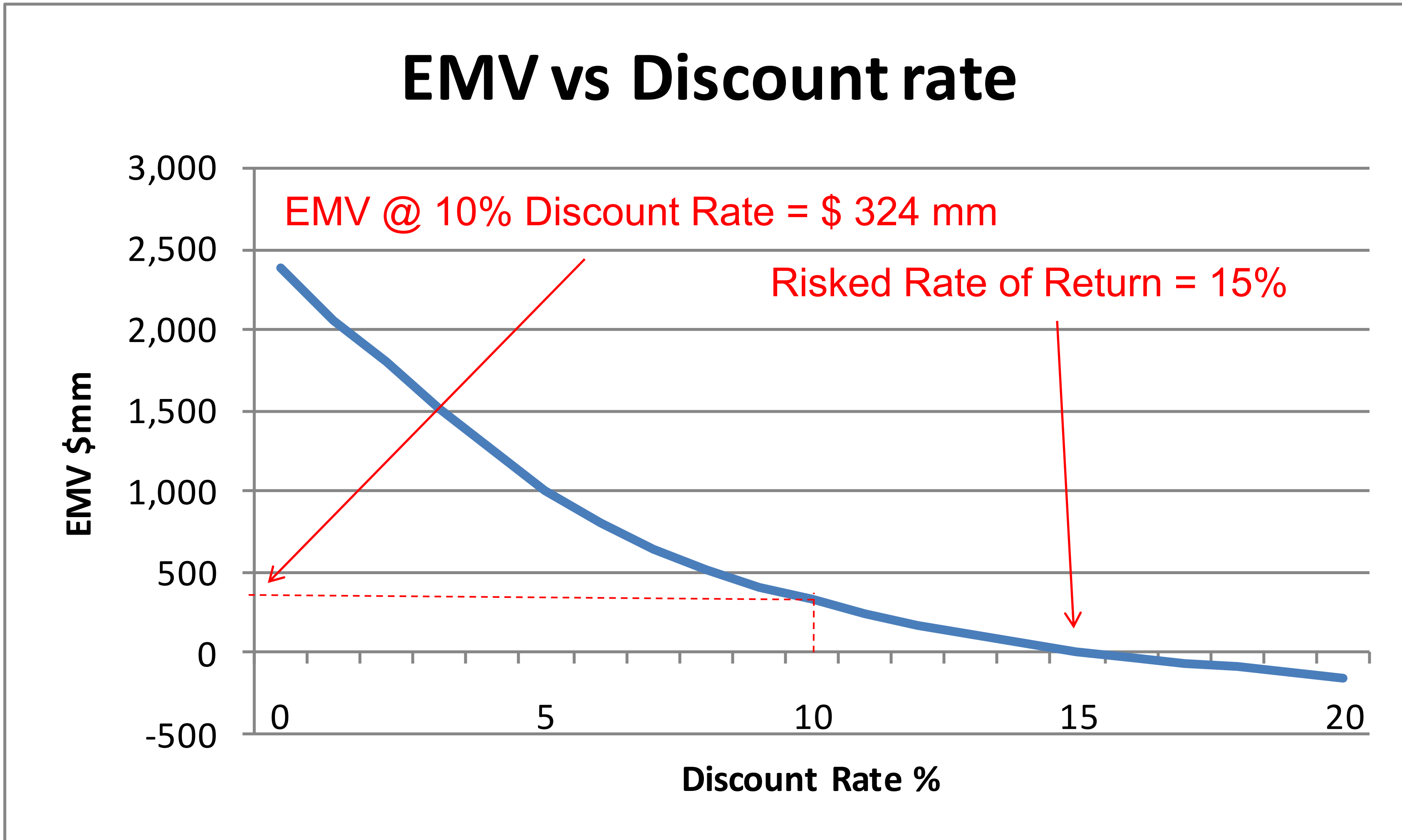
N.B. If the field is viable over the entire range then assume the NPV of the 50% case equals the EPV

Decision Tree Analysis



This is called the Expected Monetary Value (EMV) at the discount rate used.

Risked Rate of Return



Exploration Proposal

‘It is recommend that the company drill an exploration well on the prospect at a cost of $50mm.

The probability of discovering oil is 20% (in in 5). The mean discovery case has a recoverable reserves level of 900 million barrels of oil and a NPV @ 10% discount rate of $1,900mm.

Risked exploration economics indicate an Expected Monetary value of $324mm @ 10% discount rate and a Risked Rate of Return of 15%.’

Decisions on incremental investments

- I have discovered something new about the field
- I need to make an investment to enhance production
- Should I go ahead?
- How to adapt model?

The Development Decision

Congratulations – you discovered oil at a level just above the mean reserves case.

The exploration well, in addition to confirming a discovery, has provided useful information on reservoir quality, well flow rate and oil quality.

Your share price has soared but you now need to drill four appraisal wells to narrow the uncertainty on the reserves range, work out what it will cost to develop the discovery and what the economics of the project are before you go to the banks and your shareholders to raise more capital.

Reacting to a momentous event

- I have developed an oil field and spent many billions of US$
- Production has started
- The oil price collapses by 50% 2 years into the project
- How do I decide whether to continue or not?